

HOURLY RAINFALL PROBABILITIES AT SAULT STE. MARIE, MICH.

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Hourly precipitation probabilities for Lansing, Mich., prepared in 1925¹ give a fair approximation of rainfall distribution over the 24-hour period so far as the Lower Peninsula of the State is concerned. The accompanying paper has been prepared with the idea of presenting a somewhat similar arrangement, using the 22-year precipitation records of Sault Ste. Marie, Mich. This station, located at the eastern edge of the Upper Peninsula, latitude 46° 30', longitude 84° 21', is typical of that section, at least during the period considered, namely, from May to October, inclusive. During these months four regular observing stations show only slight variation as regards the number of days with 0.01 inch or more of precipitation, Escanaba averaging 68 days, Houghton 71, Marquette 77, and Sault Ste. Marie 73. The total annual rainfall for the Upper Peninsula ranges from 26 inches in western Marquette County to 34 inches in Iron County, while Sault Ste. Marie in Chippewa County has an annual total of about 31 inches, a fair average for the section.

An apportionment of the rainfall by hours as shown in Table 1 and Figures 1 and 2 reveals a maximum hourly rainfall between 2 and 3 a. m., where the six months May–October is considered as a unit. Taking the months separately, some variation from this average is to be observed. In May the maximum is found between 3 and 4 p. m.; in June and July it also falls in the p. m. period, though during the late evening hours; in August and September it occurs between 2 and 3 a. m., coinciding with the average for the six months, while in October the maximum total shifts to afternoon again, occurring during the hour ending at 6 p. m.

TABLE 1.—Total hourly amounts of precipitation (inches) May–October, for 22 years, 1905–1926, inclusive, S. Ste. Marie, Mich.

	Hours ending (a. m.) at—											
	1	2	3	4	5	6	7	8	9	10	11	12
May.....	1.95	1.50	2.04	1.92	2.11	2.55	2.46	2.25	3.11	2.71	1.74	2.12
June.....	1.92	1.54	2.02	2.39	2.31	3.54	2.50	2.11	2.91	2.20	2.29	1.84
July.....	2.12	3.09	3.00	2.54	3.06	2.27	1.81	1.38	1.09	1.41	1.36	2.20
August.....	1.65	2.75	4.73	1.88	2.91	4.46	3.50	1.94	1.94	2.26	2.19	1.54
September.....	4.08	3.19	4.75	3.80	3.21	2.25	2.62	3.95	2.14	2.52	2.98	2.17
October.....	2.50	2.77	2.61	2.82	2.64	2.45	2.43	2.84	2.07	2.56	2.52	2.39
Means.....	2.37	2.47	3.19	2.56	2.71	2.92	2.55	2.33	2.21	2.28	2.18	2.04

	Hours ending (p. m.) at—												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
May.....	1.95	2.02	2.37	3.22	1.66	2.13	1.79	2.11	1.74	1.73	1.94	1.71	50.83
June.....	2.77	2.24	2.57	2.22	3.19	2.36	2.30	1.50	1.75	2.01	4.62	2.13	57.23
July.....	1.55	1.67	2.21	3.32	2.62	3.46	1.78	3.31	2.57	3.75	2.25	2.24	56.05
August.....	1.04	1.97	3.01	2.98	1.89	2.63	4.04	3.24	1.60	2.44	2.53	1.87	60.99
September.....	3.55	2.36	2.10	1.96	1.83	1.77	2.03	1.76	1.91	2.89	2.80	3.05	65.67
October.....	1.99	1.74	2.67	2.67	3.04	3.50	2.39	2.23	2.91	3.05	3.02	1.96	61.27
Means.....	2.14	2.00	2.49	2.73	2.37	2.64	2.37	2.36	2.08	2.64	2.86	2.16

In Table 2 is given the percentage of precipitation occurring during six-hour periods, from midnight to 6 a. m., 6 a. m. to noon, etc. This grouping of hours in

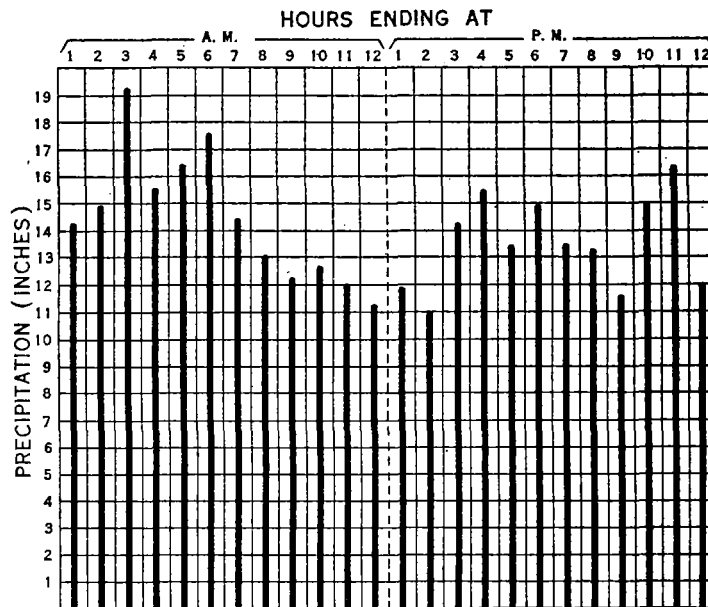


FIG. 1.—Total hourly amounts of precipitation, May to October, 1905 to 1926, inclusive, Sault Ste. Marie, Mich.

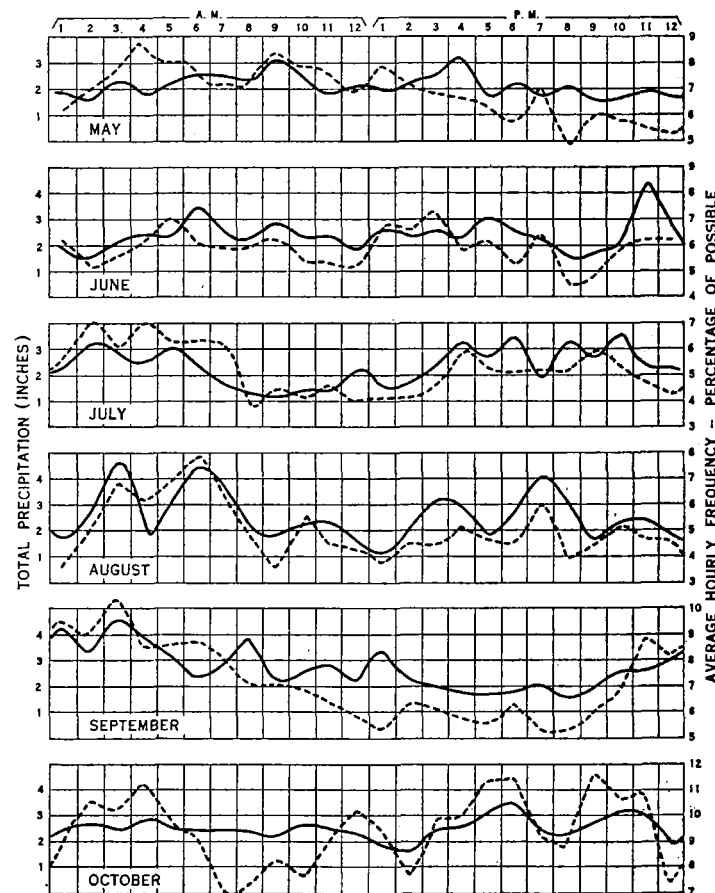


FIG. 2.—Total hourly amounts of precipitation and average hourly frequency, May to October, 1905 to 1926, inclusive, Sault Ste. Marie. Data from Table 1 (frequency equals number of times 0.01 inch or more occurred).

¹ Mo. WEA. REV. 53: 256.

relation to rainfall frequently is of value in weighing the probabilities for different periods of the day, especially in planning for insurance of outdoor events against inclement weather. For example, the percentage of rainfall at Sault Ste. Marie during September is notably greatest between midnight and 6 a. m., this period accounting for 32 per cent as against 21 to 25 per cent during the three other periods.

TABLE 2.—Percentage of monthly precipitation, occurring during six-hour periods, May–October, inclusive, S. Ste. Marie, Mich.

Month	12 mid- night to 6 a. m.	6 a. m. to noon	Noon to 6 p. m.	6 p. m. to mid- night
May.....	24	28	26	22
June.....	24	24	27	25
July.....	29	16	26	29
August.....	30	22	22	26
September.....	32	25	21	22
October.....	26	22	26	26
Means.....	28	23	24	25

In Table 3 another phase of the subject is presented, namely, the hourly frequency of precipitation, or in other words, the number of times (expressed in terms of percentage of possible times) rainfall has occurred in any measurable amount. Comparing the total hourly amounts in Table 1 with the frequency values in Table 3, we are able to gauge more definitely the average intensity of precipitation per given hour and also the relative importance of the several hourly totals in Table 1, rated by the frequency with which they are likely to occur. For example, in May the number of separate occurrences of rainfall of a measurable quantity is greatest between 3 and 4 a. m., while the maximum hourly total of precipitation in inches falls just 12 hours later, during the hour ending at 4 p. m. In this instance two heavy showers during the 3 p. m. to 4 p. m. period accounted for more than one-third of the total fall for this hour over the 22-year period, thus giving it a disproportionate rating as measured by frequency of occurrence. Taking the mean values of the tables, however, covering the six months May to October, it is to be noted that both maximum frequency and maximum hourly total in inches fall within the hour from 2 to 3 a. m., while a like agreement is found in the maximum values for September. It should be noted that the data in Tables 1 and 3 will be the more dependable if used in this comparative manner. Considered separately, especially in the case of total rainfall, a misconception of actual conditions might easily arise.

TABLE 3.—Percentage of times 0.01 or more of rain has fallen during each hour for the months May–October, 1905–1926, inclusive, Sault Ste. Marie, Mich.

	Hours ending (a. m.) at—											
	1	2	3	4	5	6	7	8	9	10	11	12
May.....	6.3	6.9	7.6	8.8	8.1	7.9	7.2	7.2	8.4	7.9	7.6	6.9
June.....	6.1	5.2	5.5	6.1	7.0	5.9	5.9	5.8	6.2	5.3	5.3	5.0
July.....	5.4	7.0	6.0	6.9	6.3	6.3	6.2	3.7	4.4	4.3	4.5	4.0
August.....	3.5	5.0	6.7	6.0	6.7	7.8	6.0	4.7	3.5	5.6	4.4	4.3
September.....	9.2	8.9	10.5	8.5	8.5	8.8	8.2	7.1	7.0	6.9	6.4	5.9
October.....	9.1	10.6	10.1	11.3	9.6	9.0	6.9	7.4	8.4	7.6	9.3	10.1
Means.....	6.6	7.3	7.7	7.9	7.7	7.6	6.7	6.0	6.3	6.3	6.2	6.0

TABLE 3.—Percentage of times 0.01 or more of rain has fallen during each hour for the months May–October, 1905–1926, inclusive, Sault Ste. Marie, Mich.—Continued

	Hours ending (p. m.) at—											
	1	2	3	4	5	6	7	8	9	10	11	12
May.....	7.8	7.2	6.9	6.6	6.4	5.6	7.0	4.8	6.0	6.0	5.4	5.3
June.....	6.7	6.4	7.4	5.8	6.2	5.4	6.4	4.4	4.8	6.0	6.2	6.2
July.....	4.0	4.0	4.7	6.0	5.1	5.0	5.1	5.0	5.9	5.3	4.7	4.4
August.....	3.8	4.5	4.4	5.1	4.7	4.6	6.0	4.0	4.5	5.8	4.7	4.7
September.....	5.3	6.5	6.2	5.9	5.6	6.4	5.4	5.3	6.1	6.9	8.1	8.3
October.....	9.3	7.5	9.8	9.8	11.2	11.3	9.1	8.7	11.6	10.6	10.7	7.4
Means.....	6.2	6.0	6.6	6.5	6.5	6.4	6.5	5.4	6.5	6.4	6.8	6.0

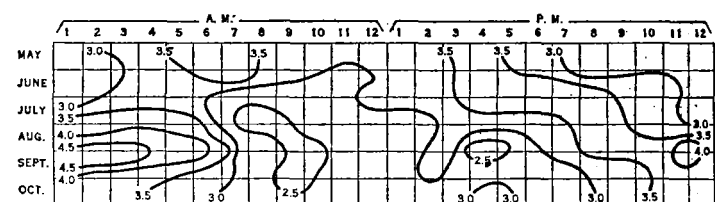


FIG. 3.—Percentage of frequency of 0.10 inch or more precipitation within three-hour period, beginning 12 midnight, 1 a. m., 2 a. m., etc. Data for 22 years, 1905 to 1926, Sault Ste. Marie.

A more detailed and specific table of frequencies is shown in Table 4 and Figures 3, 4, 5, especially adapted to the use of those interested in planning rainfall insurance, in which the usual requirement for verification is 0.10 of an inch within the specified period. The data contained in this table are simply an elaboration of Table 3.

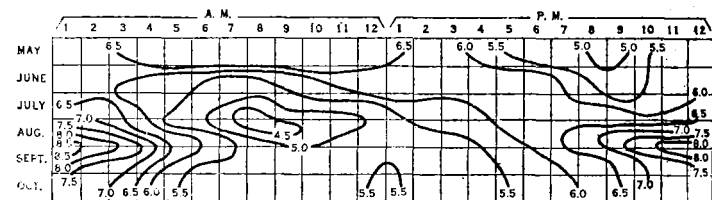


FIG. 4.—Percentage frequency of 0.10 inch or more precipitation within six-hour period beginning at 12 midnight, 1 a. m., 2 a. m., etc. Data from 22 years' records Sault Ste. Marie.

In the latter, 0.01 of an inch, the smallest measured quantity, was made the basis, and the time period was one hour. In the present calculation the basis of quantity has been increased to cover 0.10 or more; the time period, while including that for a single hour, also covers groups of hours, 2, 3, 4, 5, and 6. For example, in May

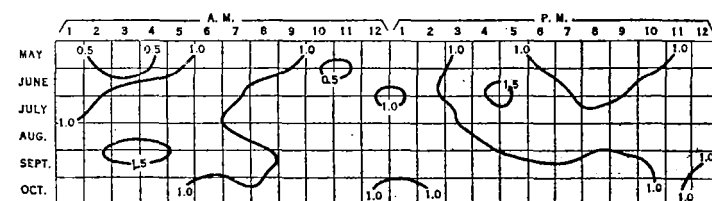


FIG. 5.—Hourly frequency of 0.10 inch or more precipitation. Data for 22 years, 1905 to 1926, Sault Ste. Marie (0.10 within one hour)

the single hour beginning at midnight has a frequency of 0.9, the two hours beginning midnight (or from 12 to 2 a. m.) has a frequency of 1.6, the three hours 12 midnight to 3 a. m. a value of 2.4, etc., while the six-hour period 12 to 6 a. m. has a frequency of 6. Taking the values by months it is found that in May the six-hour

period beginning at 3 a. m. has the highest frequency of the 24 possible groupings, the least frequency occurring in the six hours beginning at 5 p. m. In a similar manner it is possible to determine, in so far as the past performance of 22 years can form a basis, the frequency of precipitation of 0.10 of an inch or more, for the six months when recording instruments are not interfered with by freezing temperatures. The mean values for the May-October period show a maximum frequency over 3 and 4 hours beginning at 2 a. m.; that is, from 2 to 5 a. m. and 2 to 6 a. m., respectively, the maximum for five hours falling within the period from 1 to 6 a. m., while for six hours, the most favorable grouping is that from midnight to 6 a. m. Unlike the values given in Table 3, little chance is present in this latter frequency computation for misinterpreting the several results given, inasmuch as the basis of 0.10 inch is sufficiently high to cover insurance claims, thereby satisfying the main purpose of

the study. One exception should be noted, however, namely, that frequency values for a single hour, shown as the first item in Table 4, are not to be accepted with the same confidence as those covering longer periods, due to the small number of observations in which 0.10 of an inch of precipitation has occurred in one hour. Finally, it should be observed that in applying the frequency values to any particular problem, the fact that the hour of maximum frequency has been set in bold-faced type should not prejudice one to overlook other values, often but a point or so lower in the scale and for practical purposes often of equal significance. For example, in the last row of values for June, covering the six-hour grouping, though the maximum frequency of 7.3 occurs near midnight, other high values of 7 occur beginning at 5 a. m. and 9 a. m. In this case the two secondary maxima are sufficiently high to warrant considering them as well as the extreme maximum for the 24 hours.

TABLE 4.—Percentage frequency of the occurrence of 0.10 inch or more precipitation within 1, 2, 3, 4, 5, and 6 hours beginning at midnight, etc., for 24 hours at Sault Ste. Marie, Mich. (years 1905-1926, inclusive)

Month	Length of period (hours)	Period beginning (a. m.) at—											Month	Length of period (hours)	Period beginning (p. m.) at—												
		Mid-night	1	2	3	4	5	6	7	8	9	10			11	12	1	2	3	4	5	6	7	8	9	10	11
May	1	0.9	0.4	0.4	0.6	0.4	0.9	1.2	1.0	1.0	0.7	0.3	0.4	May	1	0.4	0.6	0.9	1.0	0.6	0.4	0.4	1.0	0.3	0.4	1.0	0.3
	2	1.6	1.5	1.9	2.2	1.9	2.8	2.4	2.4	2.2	2.1	1.6	1.0		2	1.6	2.1	2.5	2.1	2.1	1.2	2.1	1.6	1.3	1.3	2.1	1.5
	3	2.4	2.6	3.1	3.2	3.5	4.0	3.7	3.1	2.9	2.9	2.4	2.2		3	2.6	3.2	3.4	3.8	2.8	2.8	2.4	2.1	2.1	2.2	2.9	1.8
	4	3.2	4.0	4.9	4.7	4.4	5.3	4.4	4.4	4.3	3.7	3.5	4.0		4	4.7	4.3	4.9	3.8	3.7	3.1	3.2	2.2	2.9	2.6	3.1	3.2
	5	4.9	4.7	5.6	5.5	5.9	6.7	5.6	5.9	5.7	5.1	4.9	5.5		5	5.5	5.6	5.5	5.1	4.4	3.7	3.7	3.5	3.7	3.5	4.1	3.7
	6	6.0	6.5	6.5	7.1	6.3	6.5	6.9	6.8	6.0	6.6	6.8	6.2		6	6.3	5.7	6.2	5.7	4.9	4.4	6.0	4.4	4.4	4.6	4.7	5.1
June	1	0.6	0.5	1.1	0.9	1.1	1.5	1.4	0.6	1.7	0.6	0.5	1.1	June	1	1.1	1.1	1.2	1.2	1.7	1.2	1.2	0.5	0.8	0.8	1.7	0.9
	2	1.4	1.5	2.4	2.3	2.6	2.1	2.4	2.6	2.7	1.7	2.1	2.4		2	2.0	2.6	2.1	3.2	2.7	2.9	2.1	2.1	2.9	2.9	2.4	2.4
	3	2.9	2.4	3.3	3.5	3.3	3.5	4.2	3.5	3.8	3.0	3.5	3.3		3	3.8	3.3	3.9	4.2	3.8	3.8	3.8	2.9	3.5	3.3	3.5	2.6
	4	3.9	3.5	4.5	4.1	4.4	5.0	4.7	4.4	4.7	4.1	4.2	4.7		4	4.5	4.8	4.7	4.7	4.2	4.5	4.1	3.9	3.9	3.9	3.9	4.2
	5	5.0	5.0	5.0	5.2	5.9	5.9	5.9	5.4	5.8	5.3	5.9	5.9		5	5.6	5.8	5.6	5.4	5.2	5.0	5.0	4.1	4.4	4.2	5.0	4.7
	6	6.8	6.8	6.5	6.5	6.8	7.0	6.5	6.4	6.8	7.0	6.7	6.7		6	7.0	6.7	5.9	6.4	5.9	6.2	5.8	5.3	5.4	6.5	7.3	6.2
July	1	0.7	1.3	1.3	1.0	1.3	1.0	0.4	0.6	0.1	0.6	0.6	1.0	July	1	0.7	0.7	1.3	1.2	1.8	1.6	0.7	1.2	1.2	1.3	1.5	0.9
	2	2.2	2.1	2.2	2.4	2.5	1.9	1.2	0.7	1.0	1.8	1.9	1.9		2	2.1	1.5	2.5	2.6	3.1	2.5	2.2	2.8	3.1	2.2	2.1	1.8
	3	3.2	3.1	3.5	3.4	2.9	2.5	1.5	1.5	2.1	2.8	2.9	2.8		3	2.8	2.6	3.5	3.8	3.7	3.5	3.4	4.4	3.7	3.2	2.5	2.6
	4	4.1	5.0	4.6	3.8	3.5	2.5	2.4	2.4	3.2	3.7	3.5	3.4		4	3.8	4.0	5.0	4.3	4.6	4.7	5.0	4.9	4.0	3.4	3.2	3.4
	5	5.6	5.9	5.3	4.7	4.1	3.5	3.1	3.4	3.7	4.3	4.6	4.6		5	4.9	5.0	5.0	4.7	5.3	5.6	5.1	5.6	4.6	4.3	4.4	4.4
	6	6.0	6.2	5.7	4.7	4.4	3.8	3.7	4.0	4.7	5.1	5.4	5.4		6	6.2	5.4	5.9	6.2	6.8	6.5	6.0	5.7	5.0	4.7	4.7	5.1
August	1	0.7	1.3	1.8	1.0	1.5	1.3	1.3	0.7	1.3	1.0	0.6	0.7	August	1	0.3	0.7	0.6	1.2	0.9	1.3	1.5	1.2	0.7	1.8	1.0	1.3
	2	2.5	3.2	2.9	2.5	3.5	3.7	2.6	2.1	1.8	1.8	1.3	1.3		2	1.5	1.8	2.2	1.5	2.2	2.1	2.8	2.4	3.2	2.4	2.8	2.2
	3	4.3	4.3	4.6	4.6	4.6	4.7	3.2	2.9	2.9	2.6	2.1	2.4		3	2.6	3.1	2.6	2.6	3.1	3.1	3.4	3.8	3.6	3.5	3.2	3.7
	4	5.0	5.4	5.9	5.3	5.6	5.3	4.4	3.5	3.5	2.9	2.9	3.7		4	3.7	3.1	4.0	4.0	3.8	3.7	4.7	4.7	4.9	4.0	4.4	5.3
	5	6.2	6.8	6.5	6.0	6.0	5.7	4.7	4.1	3.8	3.8	3.7	4.1		5	3.8	4.6	5.1	4.7	4.9	5.6	5.6	6.2	5.9	5.6	6.0	6.0
	6	7.6	7.4	7.4	6.6	6.5	6.2	5.3	4.6	4.7	4.4	4.4	4.6		6	5.1	5.3	6.0	5.4	6.3	6.3	6.6	6.8	6.8	7.6	7.0	7.4
September	1	1.5	1.1	2.0	1.7	1.5	0.9	1.2	1.4	0.5	0.8	1.1	1.1	September	1	1.5	1.2	0.6	0.9	0.9	0.8	0.9	1.1	0.8	1.4	1.5	1.5
	2	3.6	3.9	3.8	3.5	2.9	2.7	2.4	1.8	1.2	1.4	2.1	2.4		2	2.1	2.4	1.8	1.7	1.8	1.7	1.8	2.3	2.6	2.7	2.7	2.9
	3	5.6	4.8	5.6	4.4	3.9	3.9	2.7	1.8	2.4	3.0	3.0	3.0		3	3.3	3.3	2.7	2.1	2.1	2.7	3.2	3.5	3.8	4.1	4.2	4.7
	4	7.1	6.5	7.0	5.8	5.8	4.8	4.1	3.0	3.0	3.8	4.2	4.4		4	4.4	4.4	3.6	2.9	3.3	3.9	4.5	4.7	4.7	4.8	5.9	6.7
	5	8.6	7.7	7.6	7.9	6.4	5.6	4.8	4.8	4.4	4.5	4.8	4.8		5	5.3	5.0	4.2	3.8	4.2	4.5	5.3	5.4	6.1	6.7	8.3	8.3
	6	10.0	8.9	9.5	7.9	6.7	5.8	5.9	5.6	6.3	5.6	5.9	5.9		6	5.9	5.4	5.0	5.0	5.3	6.1	6.5	7.0	7.7	9.4	9.2	10.0
October	1	1.5	1.0	0.4	0.4	0.9	0.7	1.2	0.9	0.7	0.7	0.6	0.6	October	1	0.6	0.6	0.9	1.0	1.0	0.6	0.4	0.4	0.6	0.9	0.7	0.3
	2	2.4	1.5	1.5	1.5	2.2	2.2	2.2	1.9	1.8	1.8	1.9	1.5		2	1.3	1.6	2.6	2.4	2.4	1.2	1.2	1.6	2.1	2.2	1.9	2.1
	3	2.5	2.2	2.4	2.9	2.9	2.8	3.1	2.8	2.5	2.8	2.6	2.5		3	2.5	2.8	3.4	4.3	3.5	2.6	2.2	2.9	2.8	3.1	2.9	2.5
	4	3.4	3.4	3.4	3.4	3.7	3.8	3.2	3.4	3.5	3.8	3.4	3.2		4	3.7	3.7	5.1	4.4	3.8	3.4	3.7	3.4	3.8	3.4	3.6	
	5	4.1	5.0	4.0	4.3	3.8	3.8	3.8	4.3	4.1	4.7	4.6	4.4		5	4.6	5.0	5.3	4.4	4.6	4.6	4.1	4.6	4.9	4.6	4.3	4.0
	6	5.7	5.1	4.9	4.7	4.1	4.3	4.6	5.4	5.1	5.4	4.7	4.9		6	5.9	5.1	5.7	5.7	6.2	5.4	5.1	5.6	5.1	5.3	4.9	4.3
Means	1	1.0	0.9	1.2	0.9	1.1	1.0	1.1	0.9	0.9	0.7	0.6	0.8	Means	1	0.8	0.8	0.9	1.1	1.2	1.0	0.8	0.9	0.7	1.1	1.2	0.9
	2	2.3	2.3	2.4	2.4	2.6	2.6	2.2	1.9	1.8	1.8	1.8	1.8		2	1.8	2.0	2.3	2.2	2.4	1.9	2.0	2.1	2.4	2.3	2.4	2.2
	3	3.5	3.2	3.8	3.7	3.5	3.6	3.1	2.7	2.7	2.8	2.8	2.7		3	2.9	3.0	3.2	3.5	3.2	3.1	3.1	3.3	3.3	3.2	3.2	3.0
	4	4.4	4.6	5.0	4.5	4.6	4.4	3.9	3.5	3.7	3.7	3.6	3.9		4	4.1	4.0	4.6	4.0	3.9	3.9	4.2	4.0	4.0	3.8	4.0	4.4
	5	5.7	5.8	5.7	5.6	5.4	4.9	4.6	4.6	4.6	4.6	4.8	4.9		5	5.0	5.2	5.3	4.7	4.8	4.8	4.7	4.9	4.9	4.8	5.4	5.2
	6	7.0	6.6	6.8	6.2	5.8	5.6	5.8	5.4	5.4	5.7	5.6	5.6		6	6.1	5.6	5.8	5.7	6.0	5.8	5.8	5.8	5.7	6.4	6.3	6.4